Northeast Fisheries Science Center

Science Spotlight

Contact: Shelley Dawicki
508.495.2378
Shelley.Dawicki@noaa.gov
NOAA/NMFS/NEFSC
166 Water St.
Woods Hole MA 02543

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Timing is Everything for Northern Shrimp Populations in the North Atlantic

Early Indicator of Changes in Climate, Ecosystems

Even for Northern shrimp (*Pandalus borealis*), which support commercial fisheries worldwide, timing is everything in life. The tiny creatures, eaten in shrimp rolls and shrimp salad, occupy a pivotal role in the oceanic food chain and may serve as early indicators of changing climate due to their sensitivity to temperature. Northern shrimp also seem to have an uncanny sense of reproductive timing, releasing their larvae to match the arrival of food and thus maximizing larval survival.

In a study to be published May 8 in the journal *Science,* Anne Richards of NOAA's Northeast Fisheries Science Center (NEFSC) laboratory in Woods Hole, Mass. and international colleagues evaluated the timing of the Northern shrimp between 1997 and 2008 in populations or stocks at different latitudes across the North Atlantic Ocean from Maine to Norway. The researchers also estimated the timing of spring phytoplankton blooms - the major source of food for the shrimp larvae - in each location using satellite images that show biological productivity in surface waters, commonly called ocean color.

"In the Gulf of Maine we have seen years when there is a good match in timing between when shrimp larvae are released and when the annual spring bloom begins. In these years larvae tend to have high survival rates, resulting in large year classes and a very successful fishery," said Richards, who has been studying Northern shrimp for almost two decades. "In other years that timing is off between when eggs hatch and when the spring bloom appears, leading to lower survival rates and a poorer fishery. The match or mismatch between the larvae and their food appears to be a key factor in shrimp production."

The *Science* study takes a broad view of shrimp stocks across the North Atlantic. Researchers studied populations of Northern shrimp, also called pink shrimp, in the Gulf of Maine, on the Scotian Shelf and in the Gulf of St. Lawrence, off Newfoundland and Labrador, on the Flemish Cap, off western Greenland and Northern Iceland, in the Barents Sea and off Svalbard, a group of islands between Norway and the North Pole.

The spring phytoplankton bloom occurs at different times in different latitudes because sunlight and sea surface temperatures, the primary triggers for onset of blooms, vary among regions. The researchers found a surprising tendency in each location for the shrimp eggs to hatch and the larvae to appear just as the bloom arrived.

"The interesting thing is that the timing of the hatch is strongly dependent on temperature on the ocean bottom, but the timing of the bloom is a function of several factors, including temperature throughout the water column and available sunlight," Richards said. "Yet, on average, at most of these locations, there is a close match between the hatch and the bloom. It makes perfect sense from an evolutionary perspective, but it is still surprising. Before the advent of satellite imagery, it would have been very difficult to be able to demonstrate this phenomenon across a wide geographic area."

The time it takes for shrimp eggs to develop into young shrimp, or larvae, varies significantly depending on local bottom water temperatures. In the southern Gulf of Maine off Cape Cod, the waters are relatively warm and shrimp eggs take six months to hatch, while in the cold waters off Northern Iceland the eggs take 9-10 months to hatch. This suggests that the time of mating must have evolved so the larvae are ready to hatch near the time of the bloom under average temperature conditions for each area.

Northern shrimp may serve as an early indicator of the impact of climate change since their life cycle is very temperature dependent. The species breeds once a year, usually in the summer/fall, with the female carrying eggs on her abdomen much like lobsters do until they hatch the following winter/spring. Although shrimp live most of their life in colder bottom waters, once the eggs hatch the young shrimp live near the surface for several months feeding on phytoplankton and larger zooplankton.

The authors say changing climate may increase bottom water temperatures, resulting in shorter development times for the eggs. If so, the eggs may hatch too early and be too far ahead of the spring bloom for optimum survival. However, they also say this "mismatch" in timing might not occur if warmer sea surface temperatures result in earlier spring blooms.

Richards is testing the "match-mismatch" hypothesis suggested in this study in more detail in her own research on the Gulf of Maine shrimp stock. So far, she has found a strong relationship between water temperatures, the timing and amount of plankton in surface waters, and shrimp survival rates.

"The warming trends evident in the waters in the Northeast U.S. are likely to have an impact on shrimp recruitment and survival, "Richards said. "Shrimp production may be much more variable in the future as the Gulf of Maine warms. The population there may ultimately decline if temperatures continue to increase unless the shrimp can adapt."

Lead author of the study was Peter Koeller of the Bedford Institute of Oceanography in Canada. In addition to Richards, other authors were from the United Kingdom, Canada, Iceland, Denmark, and Norway. Richards work was supported in part by the Fisheries and the Environment (FATE) program at the U.S. National Marine Fisheries Service.

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